

**EFFECTIVENESS RESEARCH OF METHOD FOR VALUES
FORECASTING OF EPIDEMIOLOGICAL DANGER INDICATORS BY
MEANS OF NEURAL NETWORK MODELING**

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Introductions. New infectious diseases pose a growing threat to the population. The rapid globalization of society has led to increased mobility of people and intensified global trade. Under such conditions, outbreaks of infectious diseases that occur in the most remote parts of the world can quickly spread to cities and regions, putting large groups of people at risk of infection. Forecasting allows us to determine the probability of a disease occurring, its scale and consequences. The purpose of epidemiological forecasting is to prevent the occurrence of infectious diseases, reduce the total number of patients and minimize the socio-economic consequences caused by epidemics.

Forecasting allows determining the probability of a disease occurrence, its scale and consequences. The purpose of epidemiological forecasting is to prevent the occurrence of infectious diseases, reduce the total number of patients and minimize the socio-economic consequences caused by epidemics [1].

Therefore, today there is a significant need to develop early warning systems in the field of epidemiological situation, in particular for automated forecasting of the level of epidemiological danger [2]. The development of methods for predicting the values of epidemiological hazard indicators by means of neural network modeling, in

particular, predicting the values of parameters relevant for decision-making by their time series by a recurrent temporal neural network, is relevant at the present stage of development of information technology. The main tools on which modern image classification algorithms are based include deep learning and convolutional neural networks (CNN) [3]. Convolutional neural networks are similar to regular neural networks, but designed for image processing.

Aim. The aim of the study is effectiveness research of method for values forecasting of epidemiological danger indicators by means of neural network modeling.

Materials and methods. The method for values forecasting of epidemiological danger indicators by means of neural network modeling allows, based on input data in the form of a sample of time-dependent values of a specified parameter during the studied period, to receive output data in the form of a sample with predicted parameter values for further forecasting the level of epidemiological danger by means of neural network modeling, and differs from existing methods in that it uses a recurrent temporal neural network with one convolutional layer to predict parameter values from their time series [4].

So, the input data of the method for values forecasting of epidemiological danger indicators by means of neural network modeling includes a sample of time-dependent values of the specified parameter during the studied period.

At Step 1, causal convolutions are performed. Performing this step ensures that the process of collapsing the number series will occur in chronological order and for each of the output values, all previous inputs will be taken into account. After that, the weights will be normalized in Step 2. As a result of performing Steps 1 and 2, the numerical values of the forecasted data are obtained. In Step 4, the input and output data sizes are checked. In Steps 5 and 6, blocking of hidden layer neurons is performed. In Step 7, causal convolutions are performed, which use a one-dimensional FCN architecture, where each hidden layer has the same length as the input layer, and a zero-length padding (kernel size of 1) is added to save subsequent layers. the same length as the previous ones. Step 8 is performed only

when the dimensions of the input and output layers do not match, in which case the residual connection is added in the form of a 1×1 convolution. At Step 9, there is a check of exhaustion of the numerical series, if there are unprocessed elements in the numerical series, a return to Step 1 is made. When the processing of all elements of the numerical series is finished, there will be a transition to Step 10, at which the formation of the resulting sample with predicted parameter values will be performed.

Accordingly, the source data of the method for values forecasting of epidemiological danger indicators by means of neural network modeling is a sample with predicted parameter values.

A software implementation of the method for values forecasting of epidemiological danger indicators by means of neural network modeling was created [5]. The .NET platform with the C# programming language was used to develop application components (Figure 1).

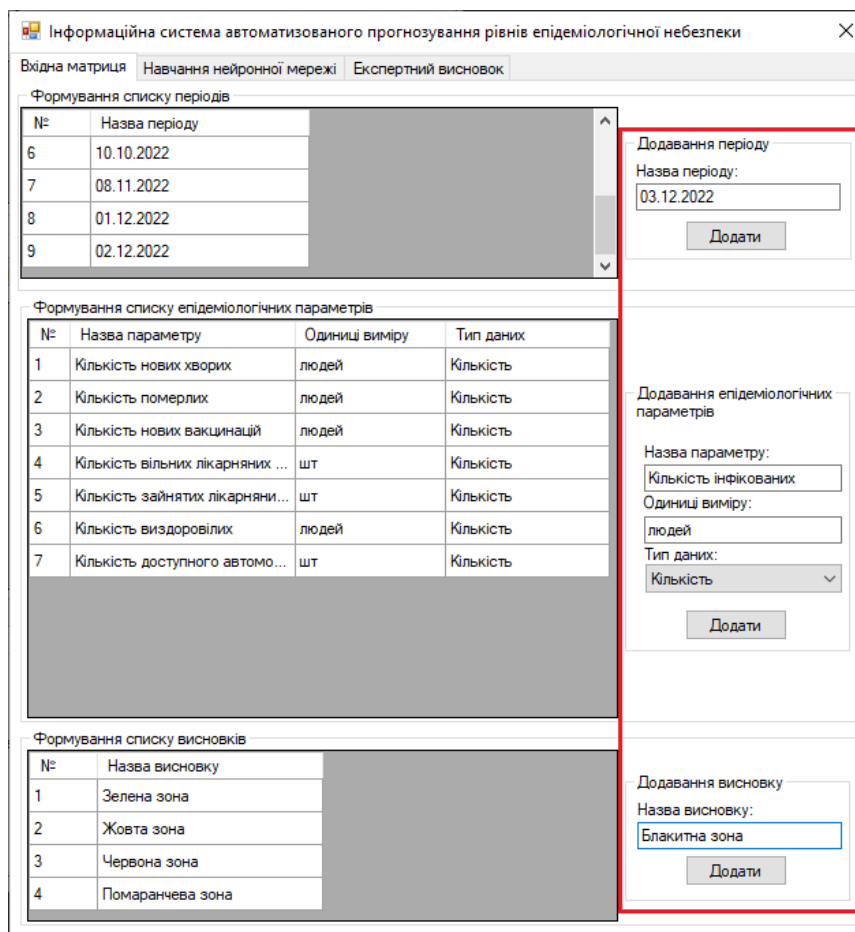


Fig. 1. Input and output matrix formation tab

The module for building input data matrices for initiating the determination of the level of epidemiological danger is designed to create a neural network architecture, which is built on the basis of the dimensions of the input and output matrix. After starting the program, the corresponding tab will open, where you need to fill in the available lists. To add new items to each of the lists, appropriate input fields are placed next to them (Figure 1).

The expert opinion generation module is designed to process data from test samples and transfer them to the inputs of a trained neural network. This module is located on the "Expert Opinion" tab. As a result, the resulting expert conclusion is formed by the neural network. The expert opinion includes the predicted version of the conclusion, which is chosen according to the highest rating, and the evaluation of each of the possible versions of the conclusion (Figure 2).

Інформаційна система автоматизованого прогнозування рівнів епідеміологічної небезпеки

Вхідна матриця Навчання нейронної мережі **Експертний висновок**

Тестова ситуація

Епохи	Кількість нових хворих, людей	Кількість померлих, людей	Кількість нових вакцинацій, людей	Кількість вільних лікарняних ліжок, шт	Кількість зайнятих лікарняних ліжок, шт
10.06.2022	12	10	122	40	23
12.07.2022	54	11	100	23	65
11.07.2022	32	15	111	54	25
15.08.2022	36	12	143	76	62
20.09.2022	68	18	123	15	45

Формування експертного висновку

Експертний висновок

Прогнозований висновок: Помаранчева зона

Оцінка кожного з можливих варіантів

Назва	Імовірність
Помаранчева зона	0.842
Червона зона	0.734
Жовта зона	0.043
Зелена зона	0.001

Fig. 2. Results of expert assessment of the test sample

Applied implementation of the components of the information system of automated forecasting of the levels of epidemiological danger ensures forecasting of the level of epidemiological danger and assessment of each of its parameters.

Results and discussion. In order to evaluate the effectiveness for values forecasting of epidemiological danger indicators by means of neural network modeling, a study of the accuracy of forecasting epidemiological parameters was conducted in relation to a different number of learning epochs of the neural network based on real data.

The data set of the spread of the coronavirus disease, which includes data on cases of infection and mortality collected from all over the world since the beginning of the pandemic, was used for the study. This data set is publicly available in the WHO dashboard.

The essence of the study is to compare the accuracy of forecasts of epidemiological parameters at different numbers of study periods. During the study, 5 iterations of recurrent temporal neural network training with a convolutional layer were performed to predict the number of new cases of infection for a period of 14 days, the accuracy assessment was performed using the `precision_metrics()` method from the Darts library. The obtained research results are presented in Table 1.

Table 1

Accuracy of predicting the number of new cases of the disease

No	Number of training epochs (iterations)	Prediction accuracy (percentage)
1	50	67.29
2	150	68.12
3	300	69.74
4	450	74.63
5	700	79.22

Having analyzed the results obtained during the study of the accuracy of forecasting the number of new cases of the disease, it is possible to note a proportional relationship between the number of training epochs and the accuracy of

forecasting, the greater the number of training epochs, the better the accuracy of the forecast (Figure 3).

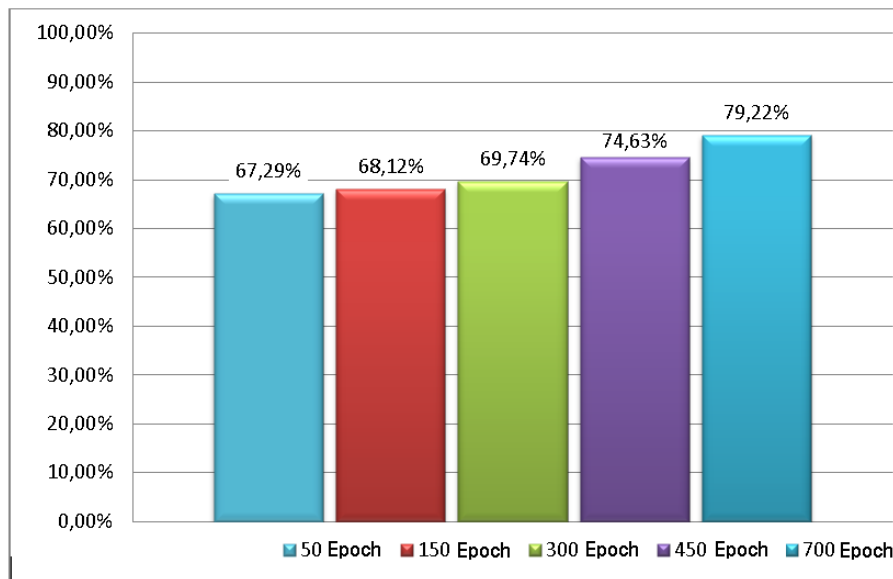


Fig. 3. Comparison diagram of the accuracy of forecasting the level of epidemiological danger according to the number of training epochs, %

Thus, in order to evaluate the effectiveness of the method for values forecasting of epidemiological danger indicators by means of neural network modeling, a study was conducted on the accuracy of forecasting epidemiological parameters in relation to a different number of training epochs of the neural network based on real data, and a comparison of the accuracy of the forecast between the method of forecasting the values of parameters by means of their time series by a recurrent temporal neural network with a convolutional layer and the linear regression method. The conducted studies established that increasing the number of studied epochs in the form of parameter samples for the maximum possible previous range leads to a corresponding increase in the accuracy of forecasting the level of epidemiological danger. Thus, after analyzing 50 samples of relevant parameters during the researched period, the accuracy of forecasting was 67.29%, and when analyzing 700 samples of relevant parameters during the researched period, the accuracy of forecasting increased to 79.22%.

Conclusions. The method for values forecasting of epidemiological danger indicators by means of neural network modeling was studied, which allows, based on

input data in the form of a sample of time-dependent values of a specified parameter during the studied period, to receive output data in the form of a sample with predicted values of the parameter for further forecasting of the level of epidemiological danger by means of neural network modeling, and uses a recurrent temporal neural network with one convolutional layer to predict parameter values from their time series.

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